MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN

Kazakh National Research Technical University named after K.I.Satbayev

Institute of Architecture, construction and energetics named after T.K.Bassenov

Department "Construction and construction materials"

Berikbolova Aidana Bakytzhankyzy

«Technological complex for the production of polypropylene pipes with a capacity of 3 million linear meters per year in Aktau»

EXPLANATORY NOTE

to the final thesis

Specialty 5B073000 – Production of building materials, products and structures

Almaty 2019

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APPROVED
Head of the department "Construction and construction materials"
____________ Kyzylbaev N.K.
"___" _________ 2019

THE TASK
to complete the final thesis

Teaching student *Berikbolova Aidana Bakytzhankyzy*
Topic: *Technological complex for the production of polypropylene pipes with a capacity of 3 million linear meters per year in Aktau*
Approved *by order of the Rector of the University №____ dated "__" ______2019 y.*
Deadline for completed work: *"___" _________ 2019 y.*
Baseline data to work: *Technological complex for the production of polypropylene pipes with a capacity of 3 million linear meters per year in Aktau*
The list of questions to be developed in the thesis project:
a) technological part
b) heat engineering part
c) architectural and construction part
d) economic part
The list of graphic material: general plan of the enterprise, plans and sections of the main production departments of the enterprise, the technological scheme of production, technological map of the product, technical and economic indicators of the plant
List of graphic material: ____ *slides of the work presentation are presented*
Recommended main literature:
1 V.A.Egorov «Polypropylene» Chemistry Publishing House Moscow 2001
2 Yu.B.Barabanshchikov, «Construction materials and products», book, «Academy", Moscow 2013.
3 GOST 32415-2013 Thermoplastic pressure pipes and their connecting parts for water supply and heating systems. General technical conditions

CONTENT

АҢДАТПА

Бұл дипломдық жобаның мақсаты Ақтау қаласында жылына 3 миллион желілік метрлік полипропилен құбырларын өндіру технологиялық кешенін құру болып табылады.

Жобалау кезінде технологиялық және жылу техникалық есептер шешілді, бас жоспар бойынша сәулет-құрылыс жоспарлау шешімдері жүргізілді, негізгі және қосалқы нысандардың орналасуы жасалды, негізгі техника-экономикалық көрсекіштері есептелді.

Дипломдық жоба 44 беттен тұрады, оның ішінде 14 кесте, 3 сурет, 2 қосымша, 15 сілтеме.

Түйінді сөздер: полипропилен құбырлары, полипропилен, өндіру, технологиялық кешен.

АННОТАЦИЯ

Целью данного дипломного проекта является проектирование технологического комплекса по производству полипропиленовых труб производительностью 3 млн погонных метров в год в городе Актау.

При проектировании выполнены технологический и теплотехнический расчёты, обоснованы архитектурно-планировочные решения по генеральному плану, произведена компоновка основных и вспомогательных объектов, рассчитаны основные технико-экономические показатели.

Дипломный проект изложен на 44 листах, включает 13 таблиц, 3 рисунка, 3 приложений, 15 литературных источников

Ключевые слова: полипропиленовые трубы, полипропилен, производство, технологический комплекс.

ANNOTATION

The purpose of this graduation project is to design a technological complex for the production of polypropylene pipes with a capacity of 3 million linear meters per year in the city of Aktau.

When designing, technological and heat engineering calculations were made, architectural planning decisions were justified according to the master plan, the layout of the main and auxiliary facilities was made, the main technical and economic indicators were calculated.

The diploma project is presented on 44 pages, includes 14 tables, 3 figures, 3 applications, 15 references

Key words: polypropylene pipes, polypropylene, production, technological complex.

INTRODUCTION

Now days, polymeric materials are widely used in almost all sectors of the industrial sector, in everyday life, including for the manufacture of important modern building materials. World production of polymeric materials is constantly growing.

In modern market conditions, the actual problem for the enterprise is the expansion of the product range while maintaining the competitiveness of products, that is, improving the strength characteristics and improving the appearance of products.

Recently, polymeric materials have become very popular. Its characteristics, such as lightness, durability, resistance to corrosion, elasticity and unpretentiousness, have made plastic pipes indispensable in all spheres of our life [1].

In Aktau, construction volumes are increasing every year, so the need for building materials and products used for the construction of buildings and structures, as well as for engineering and water communications, is increasing.

In connection with the increase in production capacity of existing plants and the need to build new ones, the need for the production and production of building products increases. One of such products are polypropylene pipes. Given the above facts, the construction of a technological complex for the production of polypropylene pipes is necessary and timely.

Since 2010, plastic is considered to be predominant among other materials used in construction and other areas. This is due to its convenience and practicality, minimal resource consumption and other performance characteristics. Pipes made on the basis of plastic also have a number of advantages that still make these products popular in the market.

In this thesis project provides for the design of a new technological complex for the production of polypropylene pipes in the city of Aktau. The advantage of the construction of this complex in the city of Aktau is the availability of raw materials for the production of pipes, which is one of the main criteria for the construction of factories. The nomenclature and production technology of polypropylene pipes has been determined. The most important factors in the production of the technological complex in Aktau are the availability of vehicles, railway lines, a seaport, water supply systems and gas supply systems of the region.

The project for the production of polypropylene pipes is environmentally friendly and safe.

1 Technological part

1.1 Mode of operation of the technological complex

The calculation of the operating mode of the technological complex is the basis for calculating the technological equipment, the consumption of raw materials and the composition of workers. The mode of operation of the technological complex is characterized by the number of working days per year, the number of working days per year, the number of working shifts per day and the number of working hours per shift. The product of these three indicators is determined by the nominal annual fund of the operating time of the plant or its individual workshops.

When assigning modes of operation, one should strive to avoid a three-shift organization of labor, only in the case when it is not required by technological standards.

As a result, the following operation mode was chosen for this technological complex:

- admission department – discontinuous week, 1 shift;
- preparatory and extrusion department – in 2 shifts.

The nominal annual fund of working time of equipment on the limits is determined by the formula:

$$T_y = N \cdot n \cdot t = 250 \cdot 1 \cdot 8 = 2000 \text{ days}$$

where N – the number of working days per year;

n – the number of shifts per day;

t – the duration of the work shift in hours.

The estimated time of operation of technological equipment in hours on a continuous and discontinuous week, on the basis of which the production capacity of the whole individual lines is calculated, is determined by the formula:

$$T_{est} = D \cdot H \cdot K_{eq} = 365 \cdot 8 \cdot 0{,}9 = 2628 \text{ days}$$

where D – the number of working days per year, h;

K_{eq} – average annual utilization rate of equipment (0,8-0,95);

H – the number of working hours per day.

Estimated working time of continuously operating equipment per year:

$$T_{est} = T_y \cdot K_{t.u.} = 2000 \cdot 0{,}9 = 1800 \text{ days}$$

For the systematic repair of equipment was selected the coefficient of technical use of equipment $K_{t.u.}$ = 0,8-0,95.

The number of working days per year for discontinuously operating lines can be determined by the formula:

$$TP = 365 - (W+H) = 365 - (100+15) = 250 \text{ days}$$

where W – the number of days off at a five-day work week;
H – the number of holidays.
Adopted in the factory operation mode is reduced in table 1.

Table 1 – Mode of operation of the technological complex

Redistribution items	Amount		Duration		Annual fund of working time, hour
	working days per year	shifts in one day	working week, day	shift, hour	
Reception of raw materials	250	1	5	8	2000
Extrusion line	250	2	5	8	4000
Packing and storage	250	2	5	8	4000

1.2 Characteristics of raw materials

Polypropylene (CH_2 – $CHCH_3$ -) n is the product of the polymerization of propane gas-forming, which is released during the cracking of oil [2].

Raw materials for the production of polypropylene pipes are used in the ratio: 70% - polymer, 30% - additives.

The quality of raw materials - polypropylene greatly affects the quality of the finished product, as well as the speed of production. The better the polymer, the faster the extrusion process can be carried out [3].

Polymers with a high degree of crystallinity go to the production of pipes, the molecular weight of which corresponds to a viscosity number of 330-350. The content of the isotactic fraction should be more than 90%, and the volatile fraction at 2000 ° C is not more than 0,2%. Pipes for the construction of an external water supply network are made of a polymer containing 2 - 2,5% of carbon black.

Raw PP is supplied from a local PP pipe factory of the city of Aktau by a motor vehicle. Polypropylene enters the factory in the form of solid white granules, packed in plastic bags.

The properties of polypropylene are given in table 2.

Polypropylene due to its paraffin structure has high strength to the action of various chemical reagents, even at high concentrations [1].

At normal temperatures, isotactic propylene is very resistant to organic solvents, even after prolonged exposure to them. By resistance to cracking during prolonged contact with SAM, polypropylene is much better than polyethylene [1]

Table 2 – Properties of polypropylene

Properties	**Value**
Molecular mass, μ, g/mol	35 000-150 000
Density, ρ, kg/m^3	870-940
Tensile strength, $R_{pac,}$ MPa	24-35
Tensile strength at break, kg/cm^2	260-400
Melting point, Tm, ^{0}C	160-170
Degree of crystallinity, %	50-75
Relative extension	500-700
Water absorption by mass in 24 hours, %	0,005%
Martens heat resistance, ^{0}C	100-110
Coefficient of linear thermal expansion	11,1
Temperature limit of use, ^{0}C	140-150

The main advantage of polypropylene is a long service life. It is possible subject to the manufacturer's recommendations regarding the specific type of product. Polypropylene is the second most important plastic, after polyethylene. The estimated duration of use of pipes is at least 30 years, for cold water systems - up to 50 years. At the same time, a short-term increase in temperature and pressure does not significantly affect the service life of polypropylene pipes [4].

1.3 The range of products

Table 3 – Product range

Mark	Options			Reinforcement	Weight l.m, g
	Diameter of pipe, mm	Wall thickness, mm	Length, m		
PPH PN20 20*3,4	20	3,4	4	-	101,74
PPH PN20 25*4,2	25	4,2	4	-	130
PPH PN 20 32*5,4 	32	5,4	4	-	169,56

Continuation of table 3

PPR PN25 20*3,4 	20	3,4	4	MR	102
PPR PN25 25*4,2	25	4,2	4	MR	130
PPR PN25 32*5,4	32	5,4	4	MR	170

1.4 Material balance

To perform the material calculation and equipment selection, it is necessary to know the annual capacity of the designed production (G), expressed in tons, in meters or square meters of the output. According to the annual production capacity, the following values are calculated [5]:

– hour production capacity (linear m / h) according to the formula:

$$G_h = \frac{G*10^3}{t_d} \tag{1}$$

Where t_d – the actual annual fund for the time of continuous equipment operation, h / year.

The actual annual fund of equipment operation time is taken according to the company's data or calculated according to standard coefficients as follows

$$t_d = t_n * K_u \tag{2}$$

where t_n– the nominal annual time fund, h / year, equal to:

$$t_н = (D_c - D_d) * t_{day} \tag{3}$$

where D_c – number of calendar days per year;

D_d– the number of days of operating idle time: this number includes weekends (104 – with two days off, 52 - with one weekend per week) and holidays;

t_{day}– the duration of the equipment for a day, h;

K_u- equipment utilization over time:

$$K_u = 1 - K_{rm} - K_t \tag{4}$$

where K_{rm}, K_t – coefficients taking into account the loss of time to repair equipment and technological changeover, respectively. $K_{rm} = 0{,}051;\ K_t = 0{,}086$ for the production of PP pipes.

Hourly consumption of raw materials (G_c, kg/h) is determined by the formula:

$$G_c = G_h * H_r \quad (5)$$

where H_r – the rate of consumption of raw materials per unit of production (per kilogram, linear meter, etc.).

The consumption rate of raw materials is calculated depending on the specific products according to the following method.

Losses of polymer raw materials are formed in the form of volatile products in the preparation of the composition, extrusion and processing of the resulting process waste and in the form of dust-like fractions when cutting pipes, processing waste. Waste used (for the manufacture of this or other types of products) is formed when equipment is commissioned (started up), when it enters the mode, when switching from one type of pipe to another, partly when cleaning equipment, cutting pipes, and controlling them. Solid unused waste is generated when cleaning equipment (head, auger) in the form of material leaks, etc. Waste materials also include defective polymer pipes (the thickness of the pipe walls is more or less than the allowable, the outer or inner diameter is more or less than the allowable, cracks, surface roughness, etc.). Used technological waste averages 4 - 6% of the amount of recycled material.

The rate of consumption of raw materials for the production of pipes is calculated by the formula:

$$H_r = K_r * m_0 \quad (6)$$

where m_0 – mass of a product (1 l.m);

K_r– expense ratio (coefficient of consumption).

Regulatory expenditure ratio for the production of pipes takes into account the irretrievable losses and returnable waste and can be calculated by the formula:

$$K_r = 1 + K_1 + K_2 + K_3 + K_4 \quad (7)$$

where K_1– coefficient characterizing the irretrievable losses during transportation, packaging and loading of raw materials; standard value K_1=0,005

K_2– the coefficient characterizing the irretrievable loss during extrusion K_2=0,0031;

K_3– coefficient taking into account the irretrievable loss during machining of pipes (pipe cutting, deburring); standard value = 0,001;

K_4– coefficient taking into account the lossless loss in the control of products = 0,0075.

Decision

1. We calculate the actual annual fund of the time of continuous operation of the equipment according to the formulas (2), (4):

$$t_d = t_u K_u = (1 - K_{rm} - K_t)(d_c - d_p) * t_{day}, \quad (8)$$

$$t_d = (1 - 0{,}051 - 0{,}086)(365 - 14)*24 = 7270 \text{ h}$$

2. Determine the hourly production capacity by the formula (1):

$$G_h = \frac{3\,000\,000 * 10^3}{7270} = 412 * 10^3 \text{ kg/h}$$

3. Calculate the expenditure ratio according to the formula (6):

$$K_r = 1 + 0{,}005 + 0{,}0031 + 0{,}001 + 0{,}0075 = 1{,}0066$$

4. Find the time consumption of raw materials:

$$G_c = 412 * 10^3 * 1{,}0066 = 415 * 10^3 \text{kg/h}$$

5. Consumption of raw materials per year:

$$G_y = 415 * 10^3 * 7270 * 10^{-3} = 3\,017\,050 \text{ t/year}$$

6. Calculation of the number of irretrievable losses:

– during transportation, packaging and loading of raw materials:

$$G_1 = 3\,017\,050 * 0{,}005 = 15\,085 \text{ kg/h}$$

– irretrievable loss during extrusion:

$$G_2 = 3\,017\,050 * 0{,}0031 = 9\,353 \text{ kg/h}$$

– losses during machining:

$$G_3 = 3\,017\,050 * 0{,}001 = 3\,017 \text{ kg/h}$$

– loses in product control:

$$G_4 = 3\,017\,050 * 0{,}0075 = 22\,628 \text{ kg/h}$$

7. Calculation of the amount of returnable waste:

– total is obtained returnable waste:

$$G_{vo} = 412 * 10^3 * (0{,}037 + 0{,}001) = 16000 \text{ kg/h}$$

– losses in the preparation of returnable waste:

$$G_5 = 412 * 10^3 * 0{,}001 = 0{,}41 * 10^3 \text{ kg/h}$$

– when cutting pipes:

$$G_{tr} = 0{,}2 * 0{,}001 * 412 * 10^3 = 82{,}4 \text{ kg/h}$$

– when crushing waste:

$$G_{td} = 0{,}5 * 0{,}001 * 412 * 10^3 = 206 \text{ kg/h}$$

– at granulation of a crumb:

$$G_{tg} = 0{,}1 * 0{,}001 * 412 * 10^3 = 41{,}2 \text{ kg/h}$$

– when mixing granules with fresh raw materials:

$$G_{ts} = 0{,}2 * 0{,}001 * 412 * 10^3 = 82{,}4 \text{ kg/h}$$

Used recyclable waste in the same production:

$$G^i_{vo} = G_{vo} - G_{tr} - G_{td} - G_{tg} = 16000 - 82{,}4 - 206 - 41{,}2 = 15\,670 \text{ kg/h}$$

Thus, 15 670 kg / h of returnable waste goes to the mixing operation with fresh raw materials. The ratio of fresh raw materials and return waste is taken 70:30. Then fresh raw materials are required:

$$G_{cv} = 15\,670 * \frac{70}{30} = 36\,563 \text{ kg/h}$$

In total, after mixing, secondary raw materials are obtained:

$$G_{vt.c.} = G^i_{vo} + G_{cv} - G_{ts} = 15\,670 + 36\,563 - 82{,}4 = 52\,151 \text{ kg/h}$$

1.5 Technological process of production

Currently, the main method of pipe production is extrusion. Extrusion - technological redistribution, in which the product is given a certain profile by pushing the heated mass through the mouthpiece. For the production of pipes, technological processes are used that ensure either complete automation within the process line or automation of the entire production.

The polypropylene pipe production line consists of an extrusion machine, a calibrating nozzle, a series of cooling baths, a pulling conveyor and an automatic saw [4].

All stages of the production process of pipes from polymeric materials are inseparable and are carried out synchronously on units consisting of machines assembled into a production line in accordance with the sequence of technological operations carried out on these machines. These are: melt formation carried out in a worm press; forming the pipe from the melt produced by the head; calibration of the pipe on the outer diameter in the calibrating device; cooling of the pipe in two stages: in the calibrator and the bath; continuous removal of pipes is made by the pulling device; pipe cutting is performed with an automatic saw; winding is carried out on a special winding device.

The process of pipe production is quite simple, it does not differ in labor-intensiveness and energy consumption, it is safe from the point of view of ecology.

The production of PP pipes begins with the supply of raw materials through the pneumatic conduit to the extruder dosing unit. In the dispenser, the main components are mixed. Granulated PP – 70 %, catalysts, plasticizers and coloring additives – 30 %.

Raw granules are loaded into the production machine of the extruder, where the polymer is heated and melt is produced.

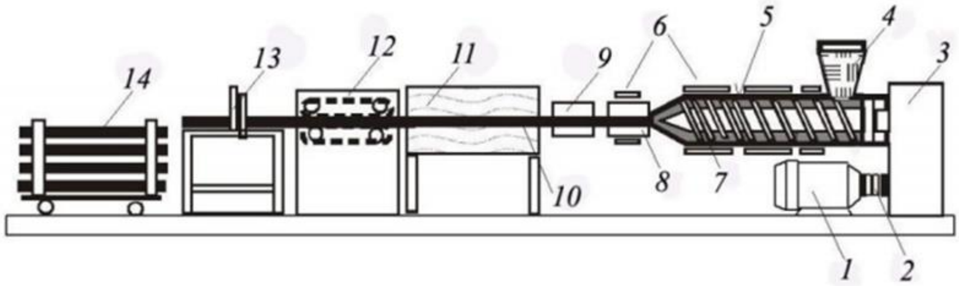
Initial processing of raw materials, which is carried out immediately after loading, occurs at a low temperature. Then, using a screw device, the plastic mass moves from one chamber to another. Along the way, the temperature in the chambers increases, and the polymer becomes more plastic. The rate of heating is in direct proportion to the requirements for the final characteristics of manufactured products. As the granules move from chamber to chamber, the temperature level increases, gradually increasing the plasticity of the material. The maximum heating level is set based on the destination of the finished polypropylene pipe. At the exit of the extreme chamber, the material takes the desired shape.

Under the influence of hydraulic equipment, raw materials are passed through a forming filter to a spinneret (made from a material that is not susceptible to the effects of high temperatures and the influence of chemical reagents). The holes in the die determine the diameter of future pipes. At this stage, the plastic is still at a high temperature and, in order to avoid material deformation, a water cooling system is used. After passing through the water cooler, the material already has a finished look, but its dimensions may not be perfect [6].

For this, there is a calibration stage. The measuring apparatus measures the product and passes it through a vacuum calibrator, which ensures perfect compliance with the declared parameters of the length and diameter of the pipes. The principle of calibration of the pipe billet on the outer diameter is in its pulling through a cooled sleeve, to the inner surface of which the workpiece is pressed either by compressed air or atmospheric pressure.

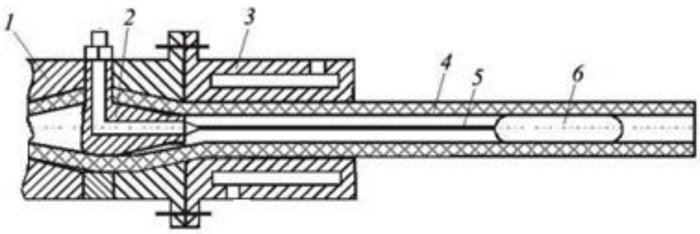
"Water shower" helps to maintain the shape of the products, but to obtain accurate dimensions, the blanks are sent for calibration. At this final stage, the following happens. With the help of a special measuring device, the current dimensions of the workpiece are compared with standard indicators. The semi-finished product is passed through a vacuum calibrator, as a result of which polymer pipes acquire the required diameter and profile. Production line is cut into the desired length of the segments.

Finished polypropylene pipes are divided into specified lengths of 4 meters, marked. Next comes the packaging and storage of finished products.



1 - electric motor; 2 - coupling; 3 - gearbox; 4 - granule bin; 5 - extruder cylinder; 6 - heating elements; 7 - worm with variable pitch screw thread; 8 - extrusion (forming) head; 9 - calibrator; 10 - pipe product; 11 - cooling bath; 12 - pulling device; 13 - cutting mechanism; 14 - stacker

Figure 1 – Scheme of the extrusion line for the production of PP pipes



1 - head housing; 2 - mandrel forming head; 3 - calibrating nozzle; 4 - polymer pipe; 5 - fastening cable plugs; 6 - floating cork

Figure 2 – Calibrating pipe nozzle on the outer diameter:

1.6 Calculation and selection of process equipment

Preparation of the polymer material for molding, its heating, kneading and homogenization are carried out using a rotating auger in the extruder barrel. The screw is characterized by the following main geometrical parameters (Fig. 1.3): diameter (D); length (L); screw thread pitch (t); depth of cut (h); the width of the crest of the coil (e); the size of the gap between the screw ridge and the inner wall of the cylinder (σ), the elevation angle of the screw auger screw (φ) [6].

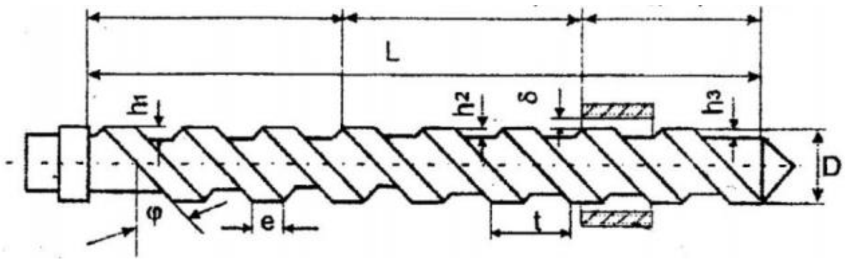


Figure 3 – Extrudeк screw

Extruder Performance Calculation:

1. Determine the geometrical parameters of the screw:

– depth of the spiral channel at the beginning of the loading zone (under the hopper) h1 by the ratio h_1= (0,12/0,16))D:
  h_1 = 0,13D = 0,13*9 = 1,17 sm;

– depth of the spiral channel in the dosing zone according to the formula:

$$h_3 = 0{,}5\left|D - \sqrt{D^2 - \frac{4h_1}{i}(D\text{-}h_1)}\right|, \qquad (9)$$

$$h_3 = 0{,}5\left|9 - \sqrt{9^2 - \frac{4*1{,}17}{2{,}3}(9-1{,}17)}\right| = 0{,}467 \text{ sm}$$

– the depth of the spiral channel at the beginning of the compression zone by the formula:

$$h_2 = h_1 - \frac{h_1 - h_3}{L}L_0 = 1{,}17 - \frac{1{,}17 - 0{,}467}{225}112{,}5 = 0{,}818 \text{ sm}$$

– average cutting depth in the pressure zone of the screw:

$$h_a = \frac{h_2 + h_3}{2} = \frac{0{,}818 + 0{,}467}{2} = 0{,}643 \text{ sm}$$

– the width of the crest of the coil e taken from the ratio e = (0,06 ÷ 0,1)D:

e =0,08D=0,08*9=0,72 sm

– cutting step is taken from the ratio t = (0,8 ÷ 1,2)D:

t = D = 9 sm

- the radial clearance between the screw ridge and the inner wall of the cylinder is taken from the relations ($\delta = \left(1 * \frac{10^{-3}}{3} * 10^{-3}\right)$ D)=0,018sm:
- lifting angle screw helix find by the formula:

$$\varphi=\text{arctg}(t/\pi D)=\text{arctg}(9/3{,}14*9)=17{,}6$$

- diameter of the core (shaft) of the screw at the hopper:

$$d_1 = D\text{-}2h_1 = 9 - 2 * 1{,}17 = 6{,}66 \text{ sm}$$

- diameter of the core (shaft) of the screw in the dosing zone

$$d_3 = D\text{-}2h_3 = 8{,}066 \text{ sm}$$

4. We calculate the coefficient of geometrical parameters of the screw by the formula:

$$\sigma=1\text{-}\ \frac{6{,}9\,D}{2(h_2-h_3}\lg\frac{h_2}{h_3}+\frac{D^2}{2h_2h_3} = 1 - \frac{6{,}9*9}{2(0{,}818-0{,}467)}\lg\frac{0{,}818}{0{,}467}+\frac{9^2}{2*0{,}818*0{,}467} = 85{,}484$$

5. We calculate the coefficients a and b by the formulas:

$$a=\frac{\pi^2}{h_2h_3}\left[\frac{D(h_2+h_3)}{2h_2h_3}-1\right] = 364{,}88 \text{ cm}^{-2},$$

$$b=\frac{2{,}3}{(h_2-h_3)}D^3\lg\frac{h_2(D+D_3)}{h_3(D+D_1)}+\frac{2h_2h_3+(h_2+h_3)D}{2D^2h_2^2h_3^2} = 0{,}523 \text{ sm}^{-4}$$

6. Determine the constant flow:
- direct A_1 = 53,81 sm^3;
- reverse B_1 = 4,25*10^{-4} sm^3.

7. We calculate the performance of the extruder:

$$Q=\frac{A_1Kn}{K+B_1C_1} = 2442\frac{sm^3}{min},$$

$$Q_ч = \frac{60Q\rho_p}{10^6} = 115{,}8 \text{ kg/h}$$

where ρ_p – polymer melt density at extruder outlet, kg/m^3

8. Calculation of the maximum melt pressure (P_m) at the end of the auger:
- length of the dosing zone:

$$L_д = 4t = 4*9 = 36\ sm$$

– maximum melt pressure at the end of the screw:

$$P_m = \frac{\pi D L_д \eta n}{h_{ср}^2 tg\varphi} = \frac{3{,}14 * 9 * 36 * 0{,}93 * 10^3 * 50}{60(0{,}64)^2 * 0{,}318} = 6{,}1 * 10^6 Па = 6{,}1 MPa;$$

Table 4 – Equipment list

Name of the device	Technical specifications	Amount	Dimensions, mm
1. Extruder EX 20*25	The number of worms - 1; The diameter of the worm is 125 mm; Installed power of electric heaters - 1.5 kW The number of revolutions of the screw - up to 70 rpm; Screw length - 2500 mm; Productivity - 6 kg / h	6	1166×1370×2650mm
2. Vacuum bath with calibrator	Vacuum depth - 550 mm Hg; Bath water temperature - 12-14 ºC	6	6200×1800×2400 mm
3. Cooling bath	Rectangular container of vinyl plastic; Capacity - 10 m3; The length of the cooling zone is 4000 mm; Water consumption - up to 1 m3 / h	6	4400×630×1206 mm
4. Pulling and counting device	Pipe pulling speed - up to 30 m / min; Motor power - 2.4 kW	6	1830×770×18800 mm
5. Cutting device	Compressed air pressure on the cutting mechanism - up to 0.4 MPa; Motor power - 0.75 kW	6	1675×1045×1600 mm
6. Receiver and packing stand	Stand, located on four legs-supports	6	6200×1700×500 mm
7. Device for the design of the socket and packing stand	Stand equipped with a device for turning the pipes 180 º and a device for decorating the socket	6	6200×1700×2200 mm

1.7 Process control and quality control

Quality indicators and scope of polypropylene pipe are reflected in [7].

The properties of raw materials and the quality of the finished product of the designed enterprise must meet the requirements of current standards and specifications.

The quality of pipes is evaluated by the results of short-term and long-term tests. The first allow us to make a conclusion first of all about how mastered the technology of manufacturing pipes. For this purpose, the outer diameters are measured. The thickness of the pipe walls, as well as deviations in diameter and thickness. The strength of pipes can be judged by the tensile strength of the pipe segment height of 10mm. Dimensional stability at elevated temperatures is determined on segments of length 120mm after half an hour of exposure to glycol bath with temperature 1400^0C.

The fragility of the pipe is evaluated by the impact strength, which is determined either directly on the pipe segment, or on a special sample made of it. In addition, polypropylene pipes are periodically subjected to a short-term internal overpressure test [8].

Pipes must have a smooth and smooth outer and inner surface. On the surface of the pipes allowed a slight longitudinal streaks and waviness. Bubbles, cracks, shells and foreign inclusions are not allowed on the surface of the pipes. The color of the pipes indicate in the technical documentation for the product [9,10].

To ensure the quality of products, it is necessary to carry out control at all stages of production: input control of raw materials, current operational control and quality control of finished products. You need to provide information about the functions of the plant laboratory of technical control Department [11].

Performed quality control is shown in appendix table A.1.

2 Heat engineering part

2.1 Thermal calculation of the extruder

The processing of polymeric materials consists of complex thermal processes. The correct idea of the heat balance of the recycling process, i.e. about the equality of input and exhaust heat, allows you to set the most optimal processing conditions, gives you the opportunity to understand the impact of technological parameters on equipment performance and quality of finished products, to obtain data for economic calculations [12].

To perform a thermal calculation, it is necessary to know the thermophysical properties of polymers. These include:

1) thermal diffusivity a, m^2 / s;
2) thermal conductivity coefficient λ, kJ / m * h * C;
3) heat capacity C, kJ / kg * C
4) polymer melt density ρ, kg / m3.

These properties depending on temperature for some polymers are given in application. 2

The heat balance of the extruder is determined by the equation:

$$E_h + E_s = E_m + E_c + E_e \quad (10)$$

where E_h – heat from external heaters, kW;
E_s – the heat released during operation of the screw (the so-called dissipative heating is the internal friction heat), kW;
E_m – heat that leaves with heated material, kW;
E_c – heat carried by the cooling system (water, air, etc.), kW;
E_e – heat loss to the environment, through the extruder housing, kW.

From the heat balance equation, you can calculate the amount of heat that you need to bring to the extruder through the heating system, we get:

$$E_h = E_m + E_c + E_e - E_s$$

The components of the balance equation are defined as follows:

$$E_m = G_m * c_p(t_f - t_i) \quad (11)$$

where G_m – amount of material processed, kg / s;
c_p – polymer specific heat, kJ / (kg · C)
t_f,t_i – the final and initial temperature of the polymer, C.

$$G_M = \frac{Q}{3600} \quad (12)$$

where Q – extruder mass productivity, kg / h

$$E_0 = G_w * c_w(t_{w2} - t_{w1}) \quad (13)$$

where c_v – specific heat of water, kJ / (kg.C);
t_{w2}, t_{w1} – final and initial water temperature, C.
The amount of water G_w coming to the cooling screw, kg / s:

$$G_в = \rho FV \quad (15)$$

where ρ – density of water, kg/m^3;
F – cross sectional area, m^2;
V – water flow rate, m/s.

$$E_п = F_k\alpha(t_e - t_a), \quad (16)$$

$$F_k = \pi d_k L_k\ , \quad (17)$$

$$\alpha = (9{,}74 + 0{,}07\Delta t)10^{-3}\ , \quad (18)$$

$$L_k = L$$

where F_k – outer surface area of the extruder body;
α – heat transfer coefficient, kW/(m^2·C);
t_e – the temperature of the outer surface of the insulated enclosure; ^{o}C;
t_a – ambient temperature, ^{o}C;
d_k – case diameter with insulation, m;
L_k – body length, m

$$\Gamma_P = \left(\frac{\pi^3 D^3 \eta_1 L}{h} + \frac{QP}{\cos 2\varphi} + \frac{\pi^2 D^2 n^2 \eta_2 e L}{\delta \tan\varphi}\right) 9{,}8 * 10^{-10}$$

where D – screw diameter, cm;
n – screw rotation speed, об/s;
P – cylinder pressure, Pa;
η_1 – polymer melt viscosity in auger spiral channel, Pa·C;
η_2 – the melt viscosity of the polymer in the gap between the screw ridge and the wall of the cylinder, Pa · C;
φ – angle of screw screw cutting, degree;
e – crest width, sm;
δ – gap size between a screw crest and the cylinder, sm.

$$Q_0 = \frac{1000Q}{3600\rho_p} \quad (19)$$

where Q_o – extruder flow rate, sm^3/s;

Q – extruder mass productivity, kg/h;
ρ_p – the density of the polymer melt, g/sm^3.

$$E_n = E_m + E_e + E_c - E_s = 12{,}5+0{,}25+0{,}3-11{,}2 = 1{,}85$$

As a result of the calculation of the heat balance of the extruder, the total energy consumption per hourly output was determined, which amounted to 1,85 kW.

2.2 Calculation of heat consumption for non-production needs

The costs of non-production needs include the cost of heat for heating, ventilation and hot water at the plant.

1) Determine the maximum hourly heat consumption for heating and ventilation of a building using the formula:

$$Q_m = [aq_0\,(t_{in} - t^0_a) + q_B\,(t_{in} - t^в_v)]*V \quad (20)$$

$$Q_m=[0{,}95\times0{,}36\times(23-(-25))+0{,}1\times(23-(-10))]*32659{,}2=[0{,}342\times48+3{,}3]\times32659{,}2 = =643909 \text{ kJ/h}$$

where a – coefficient taking into account the change in specific thermal characteristics depending on climatic conditions, taken as 0,95 for the conditions of the city of Aktau;

q_0 – building thermal characteristic for heating, equal to 0.36;
t_{in} – design temperature inside the building is equal to (23^{0}C);
t^0_a – design ambient air temperature for heating design, equal to (-25);
$q_в$ – thermal characteristic of the building for ventilation, equal to 0.1;
$t^в_v$ – design ambient air temperature for ventilation design, equal to (-10);
V – building volume equal to (126×24×10,8) = 32659,2 m^3.

2) The duration of the heating season is determined (from October 15 to April 15):

$$T= 6*30*24 = 4320 \text{ h}$$

3) Determined by the heat consumption for heating and ventilation of the building for the heating season by the formula:

$$Q_c = Q_m \times T= 643909\times4320 = 2782*10^6 \text{ kJ/season}$$

4) The projected pipe plant receives heat in the form of steam from a city small HPP plant. Based on this, the hourly consumption of steam for heating and ventilation is determined:

$$P_{pc} = \frac{Q_m}{(i_n - 4{,}2 \cdot i_k) \cdot \eta} = \frac{643909}{(2574 - 4{,}2 \cdot 20) \cdot 0{,}8} = 323{,}25 \text{ kg/h}$$

where i_n – the enthalpy of steam entering the heater is equal to 2574;

i_k – the enthalpy of condensate is 20;

η – coefficient of performance equal to 0,8.

5) Determined steam consumption for the entire heating season:

$$P_{ps} = \frac{Q_c}{(i_n - 4{,}2 \cdot i_k) \cdot \eta} = \frac{2782000000}{(2574 - 4{,}2 \cdot 20) \cdot 0{,}8} = 1396586 \text{ kg/season}$$

6) Determined by the heat consumption for hot water for all workers and employees of the plant, working in 2 shifts per day:

$$Q_v = K \cdot m \cdot n \cdot c \cdot (t_h - t_a) = 0{,}75 \cdot 40 \cdot 20 \cdot 1 \cdot (65 - 10) = 33\ 000 \text{ kJ/day}$$

where К – the coefficient taking into account the number of people using the shower at the same time is assumed to be 0,75;

m – the rate of hot water consumption per person, taken to be 40-50 kg according to sanitary standards;

n – the number of people working at the plant during the day in all terms, taken to be 20;

c – heat capacity of water;

t_h – hot water temperature equal to 65^0C;

t_a - average cold water temperature 10^0C.

7) Is determined by the daily steam consumption for hot water by the formula:

$$P_{vv} = \frac{Q_{гв}}{(i_n - 4{,}2 \cdot i_k) \cdot \eta} = \frac{33000}{(2574 - 4{,}2 \cdot 20) \cdot 0{,}8} = 16{,}57 \frac{\text{kg}}{\text{day}};$$

8) The annual steam consumption for hot water is determined in the form of:

P_{vv} = 16,57*350 =5780 kg / year

The results of the calculation are summarized in table 5.

Table 5 – Heat and steam consumption for heating, ventilation and hot water supply of an industrial building

The duration of the heating season, an hour	Heat consumption heating and ventilation		Steam consumption heating and ventilation		Daily heat consumption for hot water, kJ/day	Steam consumption for hot water	
	kJ/h	kJ/ season	kg/h	kg/sezon		kg / day	kg/year
4320	643909	$2782*10^6$	323,25	1396586	33000	16,57	5780

3 Architectural and construction part

3.1 Characteristics of the construction area

Design and construction of a technological complex for the production of polypropylene pipes is scheduled in the city of Aktau.

According to the [13] 2.04-01-2017, the "Construction Climatology", the territory of Aktau belongs to the IV-G climatic subdistrict.

The design characteristics for the design on the territory of Aktau are as follows:

Climatic region - IV-G.

Area by weight of snow cover – 1 (s_o =50 kgf/m^2).

Wind pressure area – IV (w_o = 48 kgf/m^2).

Estimated winter outdoor air temperature of the coldest five days, security of 0.92 – minus 15 º C.

The average temperature of the coldest five days: $t_{с.х.п}$ = minus18^0 C

The average temperature of the coldest days: $t_{с.х.с.}$= minus 20 ºC.

The regulatory depth of soil freezing is 0.61 m.

The depth of the groundwater level is 7.0 – 20.0 m

The maximum penetration depth of 0º C into the soil is 1.00 m.

The average annual wind speed is 35 m / s.

The district's seismicity is 6 points.

During the year, the highest frequency of eastern and south-eastern, as well as westerly winds is observed. In summer, western and northwestern winds prevail. East and southeastern winds in 30.0 - 50.0% of cases are observed in winter. This is due not only to baric, but also to local thermal conditions. In winter, the waters of the Caspian are warmer than the adjacent desert, and therefore, during this period, the tendency of the colder air masses to move from the desert towards the sea increases.

The average monthly wind speeds in winter are 4 – 5 m / s, in the summer months they are lower than winter – 3 m / s, the average annual speed is 3.5 m / s. Winds of the south-east and north-west have the highest average speeds.

According to the moisture regime, the territory belongs to the desert zone. The average annual precipitation is 176 mm. Monthly rainfall is unevenly distributed. The greatest amount of precipitation falls in winter. In summer, precipitation falls in the form of short-term heavy rain, in winter - in the form of snow. The snow cover is unstable, its height can reach 5 – 10 cm.

Geology. Geomorphologically, the territory of the city of Aktau is located on the abrasion-accumulative plain of the early Hvalian age. The depth of the groundwater level is 7.0 – 20.0 m. The groundwater is brackish, the chemical composition is magnesium sulphate.

From a depth of 4.3 m to 8.3 m, the marly stratum is widespread; it is represented by marls from the fortress, clay marl weak and shell marl. All varieties of marl occur in the form of interbedding, with a capacity of 0.2 m to 1.7 m.

From the depth of 7.7 m to 10.1 m, marl limestones with a thickness of up to 11.0 m extend. At a depth of 16.1 m to 19.6 m, marl clay is deposited. The primers are highly corrosive to steel and high to aluminum..

Physico - mechanical properties of soils. Sandy-brown light-brown hard, sagging, with the inclusion of limestone rubble up to 10.0%, sediment thickness from 0.6 to 1.5m. The density of the soil is 1.45 -1.49g / cm³, the porosity coefficient is 0.85-0.99; specific adhesion 18 kPa; angle of internal friction 26 °; modulus of deformation 13 MPa (in its natural state), 4.8 MPa (in a water-saturated state); subsidence subsidence, type of subsidence - 1, initial subsidence pressure of 0.01 MPa, turnover index <0.

Shell limestone from yellow to rusty brown color, very low strength, planted, weathered in the roof, softened in water, with marl layers of very low strength, sediment thickness varies from 6.6 to 7.4 m. The density of the soil is 1.20-183 g / cm³; tensile strength uniaxial compression 1.3 MPa (in its natural state), 0.8 MPa (in a soaked state); softening coefficient 0.1-0.87; water absorption 6,6-23,0; initial landing pressure of 0.02 MPa.

According to the qualitative prediction of potential flooding, the territory is not flooded. The standard depth of seasonal freezing of soils at the Aktau meteorological station for sandy loam is 0.67 m, for large block soil it is 0.8 m. The maximum penetration depth of 0 ° C in the soil is -1.00 m.

Determining the depth of the foundations

Normative freezing depth d_{fn} (according to SNIP RK 2.01.01–2001 “Construction climatology”) -1m.

Estimated freezing depth

$$d_f = d_{fn} \cdot k_h \tag{21}$$

where k_h – thermal expansion coefficient К= 0,5

$$d_f = 1 \cdot 0,5 = 0,5 \text{ m}$$

Groundwater level at the construction site d_w = 15 m

Compare d_f и d_w

$$d_f < d_w$$

$$0,5 < 15 \text{ m}$$

According to [14] must be at least d_f

For constructive reasons, we determine the depth of the foundation:

– we add to the elevation of the basement floor min 0,5 and find the elevation of the base of the foundation

$$2,900 + 1,2 = 4,100$$

– find the difference between the marks of the bottom of the foundation and the ground

$$4{,}100 – 0{,}950 = 3{,}150$$

Structurally, we take the depth of the foundation of 3,150 m.

3.2 Justification of the decision of the master plan of the technological complex

General plan

The master plan is made in M 1: 1000.

In the upper left corner of the sheet is a wind rose for the city of Aktau.

Planning decisions are made in accordance with the wind rose. The site for the construction of the plant was assumed to be conditionally flat and with normal hydrogeological conditions

According to sanitary standards, this company belongs to the 3rd class. The sanitary protection zone corresponding to this class is equal to 100 m.

On the territory of the plant are located: an industrial building, a warehouse of raw materials, a FP warehouse, an AHC, a laboratory, a parking lot for 20 cars.

The administrative building is located on the windward side. The transition from the administrative block to the industrial building is carried out across the street. The site in front of the AHC is paved with paving slabs.

For landscaping the site of the enterprise, local species of trees and shrubs were applied, taking into account their sanitary protective and decorative properties. The main element of landscaping sites are lawns. The territory of the enterprise is fenced.

Engineering support of the plant (water supply and sewerage, electricity, heat supply) is provided by connecting to the existing networks of the settlement.

The removal of surface water has been resolved by imparting, to the planned sections and highways, slopes that ensure the flow of water according to the overall situational relief.

The geological structure of the soil for construction is favorable.

Table 6 – Repeatability of wind direction according to [13].

Months	Side of the world							
	N	NE	E	SE	S	SW	W	NW
January	15	15	16	32	3	2	6	11
July	24	17	9	7	6	9	10	18

3.3 Space – planning solution

When considering the space-planning decisions taken into account the average capacity of the plant and the need for compact production.

The height of the production building to the bottom of the load-bearing structures is 5 m.

Columns – precast concrete foundations glass type. The building blocked reinforced concrete girders slab, slab - finned, roofing - roll.

Administrative building

The building is one-storey with a height of 6.5 m. the Walls are made of face brick (wall thickness of 2.5 bricks). Foundations - monolithic, concrete.

Calculation of stock of raw materials

Calculation of polypropylene warehouse is designed as a separate building. The warehouse is a silo type.

Polypropylene comes to the warehouse of raw materials in the form of granules. It is necessary to provide sun protection and fire safety of raw materials. Therefore, the granules are stored in silos.

The required storage capacity of polypropylene kg:

$$V_s = Q_{day} * \frac{n}{K_f} \quad (22)$$

where Q_{day} – daily requirement of technological complex in PP, kg;

n – standard stock of software, days., n=7 day.;

K_f – storage tank fill factor 0,9.

$$V_s = 7000 * \frac{7}{0,9} = 54\ 444 kg$$

Table 7 – Technical characteristics of the warehouse PP

Indicators	Stock
Capacity, t	60
Number of silos, pcs	2
Electric motor power, kW	50,8
Cargo handling, thousand tons / year	23
Number of employees, people	2

Calculation of the warehouse of finished products

The warehouse area is determined from the expression:

$$A = \frac{Q_{day} \cdot T_s \cdot K_1}{Q_v} \quad (23)$$

where Q_{day} – the number of products arriving per day;

T_s – storage time;
K_1 – area loss factor;
Q_v – standard volume of products, per 1 m^2 of area, pieces.

$$A = \frac{1442 \cdot 7 \cdot 1{,}7}{280} = 61 \text{ м}^2$$

4 Economic section

Construction of a technological complex for the production of PP pipes with a capacity of 3 million linear meters / meter per year.

Project start: January 2020

Starting date of production: January 2021

Planning period: 5 years; 2021-2026 inclusive.

Discount rate: 10%.

4.1 Calculation of investment costs

Investment costs include the following cost items (table 8).

Table 8 – The composition of investment costs

Expenditures	Amount, mln.tenge	Justification
Purchase and installation of equipment	20,700	Price list of the manufacturer
Construction of buildings and structures	587,186	Estimated construction cost calculation
Total:	607,886	

4.2 Calculation of production costs

Table 9 – Structure of production costs

The name of indicators	Per unit of production, tenge	Total, thousand tenge
Volume of production, p		750000
Cost price		
Raw materials	320	238548
Water for technological purposes	2	119,552
Fuel for technological purposes	720	540900
Electricity for technological purposes	15	11241,8
Salary costs	50	36240
Payroll accruals	5	3624
Depreciation deductions	3	2290

Continuation of table 9

Maintenance and repair	0,3	229
Advertising expenses	0,03	22,4
Property tax	3	2203,35
Total cost	1110	835418,102
VAT, 12%	130	100250,17
Total	1240	935668,27

Determination of enterprise profits from the sale of annual production.

Table 10 – Calculation of income derived from the sale of pipes

The name of indicators	Units	Amount
PP pipes	pieces	750000
Price including VAT	tenge/p	2000
Total revenue	thousand tenge	1500000
Including VAT	thousand tenge	180000

Table 11 – Calculation of net profit

Indicators	Amount
Proceeds (gross income) from sales of products excluding VAT, mln. tenge	1320
Production costs, mln. tenge	835,4
Balance profit, mln. tenge	484,6
Profit tax * 20% to budget	96,92
Net profit	387,68
Depreciation charges, mln. tenge	2,29
Net profit + income from operations (depreciation), mln. tenge	389,97

The payback period of the enterprise since its launch for the production of pipes is determined as follows:

Table 12 – Calculation of payback

The cost of creating the enterprise, mln.tenge	Net profit + income from operations, mln.tenge	The recoupment of the enterprise since its launch for the production of PP pipes, years
607,886	389,97	1,6

Given that the preparatory period for the establishment of the enterprise takes 1,5 years (development of design and estimate documentation, construction and installation work, manufacturing and supply of equipment, creation of the necessary infrastructure, organizational measures, etc.), the estimated payback period of the enterprise will be:

$$Payback = 1{,}6 + 1{,}5 = 3{,}1 \text{ years}$$

4.3 Calculation of technical and economic indicators of the project

Calculation of profitability threshold (break-even point)

The break-even point is the volume of production at which revenue from product sales is equal to all the costs of producing these products.

Table 13 – Calculation of the threshold of profitability (break-even point)

The name of indicators	Per unit of production, tenge	Total, thousand tenge
Volume of production, thousand pieces		750
Proceeds from sales without VAT	2000	1320000
Variable costs:		
Raw materials	318	238548
Water for technological purposes	0,159	119,52
Fuel for technological purposes	721,2	540900
Electricity for technological purposes	14,98	11241,8
Salary costs	48,32	36240
Payroll accruals	4,83	3624
Total variable costs:	1107,5	830673
Fixed costs:		
Salary AMS	24,8	18600
Payroll accruals	2,48	1860
Depreciation deductions	3,05	2290
Maintenance and repair	0,305	229
Advertising expenses	0,03	22,4
Total fixed costs:	30,67	23001
Total cost	1138,2	853674
VAT, 12%	136,58	102440,88
Total	1274,8	956114,88
Break-even point, thousand p		199,5

The following technical and economic indicators are calculated.

The profitability of production assets R_{PA} is determined by the following formula:

$$R_{PA}= \frac{GP}{FA_{av}+C_n}*100\% = \frac{484,6}{607,886+83,54}*100\%=71\%$$

where R_{PA} – the profitability of production assets, %;

GP – gross profit, mln.tenge;

FA_{av} – the average for the period the value of fixed assets, mln.tenge;

C_n – normalized working capital (accepted in the amount of 10% of GP), mln.tenge.

The cost of basic production assets is determined by the exception of the total capital investments, the cost of preparing the construction site, improvement of the enterprise's territory, temporary dismantled buildings and structures, the maintenance of the directorate of the enterprise being built, the training of operational personnel, design and survey works.

Return on assets R_A is determined by the following formula:

$$R_A = \frac{NP}{A_{AV}}*100\% = \frac{387,68}{853,674}*100\% = 45,4\%$$

where R_A – the return on assets, %;

NP – net profit, mln.tenge;

A_{av} – the average value of assets, mln.tenge.

The profitability of the sold products R is determined by the following formula:

$$R_S = \frac{NP}{C}*100\% = \frac{387,68}{835,4} *100\% = 46\%$$

where R_S – the profitability of sales,%;

NP – net profit, mln.tenge;

C – cost of sold goods, mln.tenge.

The main technical and economic indicators in table 14.

Table 14 – Technical and economic indicators of the factory

Indicators	Unit	Value
Annual output		
a) in kind	pieces	750000
b) in terms of value	million tenge	1320
The total cost of all marketable products	million tenge	835,4
Including 1 piece	Tenge	1110
Annual profit	million tenge	387,68
Production assets	million tenge	607,886

Continuation of table 14

Including basic production assets	million tenge	547,09
Normalized working capital (10%)	million tenge	83,54
Profitability:		
a) production assets	%	71
b) sold products	%	46
Production costs for 1 tenge of commercial products	Unit	0,55
Payroll number of people employed	Person	20
Including workers		12
Annual output per worker		
a) in monetary terms	thousand tenge	66000
b) in kind	thousand p	37,5
Total estimated cost	million tenge	607,886
Specific investment	tenge / m^2	810,5
Project payback period	years old	3,1

Technical and economic indicators obtained for the plant with a capacity of 3 million linear meters of polypropylene pipes per year are generally favorable and the technological complex can be recommended for construction.

The payback period of the project is 3,1 years.

The cost and selling price for 1 meter of pipe is lower than the cost of polypropylene pipe in the construction market, which should ensure the timely sale of products.

Conclusions: the designed technological complex for the production of PP pipes with a capacity of 3 million linear meters per year in Aktau has quite positive technical and economic indicators, will allow to produce competitive, high-quality products that will ensure the sale of products and quickly recoup the costs of its construction.

CONCLUSION

The technological complex for the production of polypropylene pipes with a capacity of 3 million linear meters per year is located in Aktau. The area has favorable conditions for the construction of this complex: there is the presence of local raw materials, the possibility of transporting finished products by road, railroad, and the seaport.

When designing the technological complex, the mode of operation of the enterprise was determined: 2-shift work. Established a range of products of the enterprise. The release of unreinforced and microreinforced PP pipes with diameters of 20, 25, 32 mm was adopted.

An extrusion method for the production of polypropylene pipes has been selected. The material balance of the main technological equipment was compiled.

The calculation of auxiliary facilities of the plant was carried out, namely, the sizes of the raw materials and finished products warehouses were determined.

A master plan for the plant was developed, including a production building, an administrative building, a warehouse for raw materials and finished products, a laboratory, a parking lot, a checkpoint.

The main technical and economic indicators of the factory’s production activity were determined. The amount of investment total was 607,886 million tenge, of which the cost of the equipment – 547,09 million. tenge, for construction – 587,186 million tenge. The payback period of the factory is 3,1 years. The cost price and selling price for 1pieces of production is 2000 tenge, which is significantly lower than the cost in the construction market and this ensures timely sale of products

The projected technological complex with a capacity of 3 million meters of PP pipes per year has positive technical and economic indicators, and therefore quite competitive products will be produced, which will ensure its successful sale, as well as payback on the construction of the complex.

List of abbreviations

PP – polypropylene
PPH – a polypropylene homopolymer
PPR – random copolymer PP
SAM – surface -active materials
MR – the micro-reinforcing
HPP – heat power plant
AHC – administrative and household complex
AMP – administrative and management personnel
DSW – design and survey works
FP – finished product
MWF –monthly wage fund
APF – annual payroll fund
VAT – value-added tax

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Appendix

Appendix «A»

Table A.1 – Technical quality control of raw materials, process and quality of finished products

Name	Limit and nominal value			
Inlet control				
Material or operations	Controlled parameter	Period of control	Place of control	Control method
Polypropylene	Quality raw materials	1 time per month	Laboratory	Colour Molecular mass Density Tensile strength, Melting point Degree of crystallinity Relative extension Water absorption by mass in 24 hours Coefficient of linear thermal expansion Temperature limit of use Weight
Additives	Quality raw materials	1 time per month	Laboratory	Molecular mass Density Water absorption by mass in 24 hours Coefficient of linear thermal expansion
Optical control				
Extrusion line	Plot control	3 times per shift	Extruder section	Colour Dimensions Marking
Exit control				
Finished PP pipe	Quality of finished products	3 times per shift	Laboratory	Weight Colour Strength Stability water obligation

Appendix «B»

The structure of capital investments includes: the cost of construction of buildings and structures (industrial buildings, administrative and residential buildings, the length of the projected engineering communications), including the development of DSW, the cost of equipment, including the cost of equipment installation and others.

The estimated cost of construction is determined by the object estimate, compiled on the basis of enlarged estimated standards in the prices of 2019.

Table B.1 – Calculation of the cost of the main construction objects (in prices of 2019)

Name	Unit	Amount	Cost of units, tenge	Total estimated cost, thousand tenge
Industrial building	m^2	3000	55684	167052
Total:				167052

Table B.2 – Calculation of the cost of construction of a building and auxiliary facilities

Name	Unit	Amount	Cost per unit, tenge	Total estimated cost, thousand tenge
Administrative building (24x12)	m^2	288	60254	17253,152
Finished products warehouse	m^2	1000	21227	21227,000
Material warehouse (24x12)	m^2	288	20084	5784,192
Parking	m^2	583	12500	7287,5
Total object estimate				51551,844

Table B.3 – Local estimate for construction and installation work on energy facilities (in prices of 2019)

Name of works	Unit	Amount	Cost, thousand tenge	
			unit	full
Transformer substation	kw	62	20	1240
Low voltage cable networks	m	150	1,62	243
Telephone, radio	m	100	2,11	211
Total:				1694
Overhead	%	12		203
Total				1897

Continuation of appendix «B»

Table B.4 – Calculation of the cost of equipment

Name of equipment, brand	Unit	Amount	Price per unit, thousand tenge	Amount, thousand tenge
Extruder EX 20*25	p	6	900	5400
Vacuum bath with calibrator	p	6	700	4200
Cooling bath	p	6	500	3000
Pulling and counting-marking device	p	6	500	3000
Cutting device and packing stand	p	6	200	1200
Device for registration of the socket, and a packing stand	p	6	160	960
Dispensers	p	12	200	240
Total:				18000
Cost of installation and adjustment of equipment	%	15		2700
Total cost of equipment and installation				20700

Table B.5 – Local estimates for transport management and communications

Name of works	Units	Amount	Cost, thousand tenge	
			for 1 pieces	full
Road	m^2	500	5,98	2990
Overhead	%	12		358,8
Total				3348,8

Table B.6 – Local estimate of the cost of external networks and the construction of water supply, sewerage, heat supply and gas supply

Name of works	Unit	Amount	Cost, thousand tenge	
			for 1 m	full
Water pipes	m	180	9,717	1749
Heat pipe	m	180	26,02	4683
Sewage	m	180	6,468	1164
Total:				7596
Overhead	%	12		911
Total				8507

Continuation of appendix «B»

Table B.7 – Estimated construction cost calculation factory (Compiled in prices in 2019).

Name of chapters, objects, works and costs	Estimated cost, thousand tenge			Total, thousand tenge
	CAW	equipment	other expenses	
Chapter 1. Territory preparation	3064			3060
Chapter 2. The main construction objects	167052	20700		187152
Chapter 3. Auxiliary objects	51551,844			51551,44
Total chapter 2-3	221623,84	20700		242323,84
Chapter 4. Energy Facilities	1897			1897
Chapter 5. Transport and communication facilities	3348,8			3348,8
External engineering networks	8507			8507
Chapter 7. Improvement and landscaping	4200			4200
Total for chapters 1-7	2739576,6	20700		260276
Chapter 8. Temporary buildings and structures, 2.7%	7513,277			7513,277
Total for chapters 1-8	247089,877	20700		267789,877
Chapter 9. Additional costs				
Winter rise, 1%	2857,82816			2857,82816
One-time reward for longevity 1%			2857,82816	2857,82816
To pay for additional holidays 0.4%			1428,914	1428,914
Total chapter 9	2857,82816		4286,74216	7144,57032
Total chapters 1-9	249947,7052	20700	4286,74216	271076,4267
Ch. 10. The content of the directorate (technical supervision) of the enterprise under construction, 0,49%			21,005	21,005
Ch. 11. Training of operational personnel. 0,4%			17,147	17,147
Ch. 12. Design and exploration work, designer supervision, 4.1%			175,756	175,756

Continuation of appendix «B»

Continuation of table B.7

Total for chapters 1-12	249947,7052	20700	4500,65016	275148,3554
Total estimated calculation:				
At current prices in 2019	249947,7052	20700	4500,65016	275148,3554
Taxes, fees, obligatory payments (2%)			90,013	90,013
Estimated cost at current price level			4590,66316	275238,3684
VAT (12%)			332647,97	332647,97
Construction cost	249947,7052	20700	33728,6332	607886,3384

The production capacity of the technological complex is 3 million running meters of PP pipes per year. Production costs include costs that are directly related of pipe production.

Table B.8 – Requirement for materials

Types and names of raw materials	Annual demand, tons	Annual demand, kg	Unit price, tenge/kg	Cost thousand, tenge
PP	463,2	463200	500	231600
Auxiliary materials		3%		6948
Total				238548

Table B.9 – The need for fuel, electricity, water

Types and names of raw materials	Units	Annual consumption	Unit price, tenge	Sum of expenses, thousand tenge
Gas	m^3	$10818 \cdot 10^3$	50	540900
Water	m^3	3960	30,19	119,552
Electricity	kWh	647567,5	17,36	11241,8
Total				552261,3

Salary Costs

Plant performance refers to the enterprises of average power. In this regard, the staff number is adopted with the maximum possible combination of professions.

In total, the plant employs 20 people, 8 of them in the AMP, shop personnel 12 workers.

Administrative and management personnel, supply and sales department, planning and finance department, accounting, preparatory department, logistics and sales department, technical control department, factory laboratory, production personnel are provided for.

Continuation of appendix «B»

Table B.10 – Staff list

Position	The number of people	Salary, tg	MWF,tg	APF,tg
Director	1	400 000	400 000	4 800 000
Chief engineer	1	340 000	340 000	4 080 000
Foreman	1	200 000	200 000	2 400 000
Technologist	2	180 000	360 000	4 320 000
Mechanic	2	150 000	300 000	3 600 000
Powerman	1	150 000	150 000	1 800 000
Secretary	1	100 000	100 000	1 200 000
Personnel management manager	1	110 000	110 000	1 320 000
Chief accountant	1	160 000	160 000	1 920 000
Accountant	1	110 000	110 000	1 320 000
Head of supply and sales department	1	110 000	110 000	1 320 000
The operator of the extruder	4	100 000	400 000	4 800 000
Technician	2	80 000	160 000	1 920 000
Security	2	60 000	120 000	1 440 000
Total:	20	2 250 000	2 920 000	36240000

Depreciation of fixed assets

Taking into account the purpose and characteristics of buildings and structures, as well as the sectoral affiliation of the equipment used, the following weighted average values of depreciation deduction standards for the full restoration of the enterprise as a whole are taken:

– for buildings and structures – 2,5%
– on equipment with installation – 10%

Table B.11 – Amortization charges

Titles	Initial book value, mln. Tenge	Depreciation rate (%)	Depreciation, million tenge
Buildings and facilities	8,950	2,5%	0,22
Equipment	20,700	10,0%	2,07
Total	29,65		2,29